TELECOMMUNICATIONS AND RADIO ENGINEERING

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FTD		Concept of circuit theory	Symbol
Name	Symbol		
Distribution of active power	$\rho_a(f,\ t)$	Active power	P_a
Distribution of instantaneous power	$\rho_{inst}(f,\ t)$	Instantaneous power	$p(t)$
Distribution of reactive power	$\rho_r(f,\ t)$	Variable power	$p(t)-P$
Envelope of distribution of reactive power	$O_r(f,\ t)=\frac{1}{2}\lvert\rho_R(f,\ t)\rvert$	Reactive power	P_r
Envelope of distribution of instantaneous power	$O_{inst}(f,\ t)=\rho_a(f,\ t)+O_r(f,\ t)$	Total power	$P_{tot}=P_a+P_r$
Complex distribution	$\rho_a(f,\ t)+iO_r(f,\ t)$	Complex power	$P_{comp}=P_a+P_r$
Phase distribution	$\theta(f,\ t)=\arg[\rho_R(f,\ t)+4\pi ft$	Phase of harmonic oscillation	$\varphi(t)=2\pi f_0 t+\varphi_0$
Initial phase distribution	$\theta(f,\ t)-4\pi ft=\arg[\rho_R(f,\ t)]$	Initial phase of harmonic oscillation	φ_0

positive results; this led to a search for other versions of the analytical form of the FTD of the signal power.

The function

$$\rho_{inst}(f,t)=2z(t)[a(f)\cos 2\pi ft+b(f)\sin 2\pi ft],\ 0<f<\infty, \tag{2}$$

was suggested in [3], describing the FTD of the instantaneous power $z(t)$, where $a(f)$ and $b(f)$ are the even and odd components of the spectrum of the process being analyzed.

The function (2) for narrow-band signals, for which the value of the lower limit of the spectrum is higher than the frequency band occupied by them, has two components: a slowly varying component $\rho_a(f,t)=0.5\,\mathrm{Re}[\rho_R(f,t)]$ and a rapidly oscillating component $\rho_r(f,t)=\rho_{inst}(f,t)-\rho_a(f,t)=0.5\,\rho_{inst}(f,t)-\tilde{z}(t)[a(f)\sin 2\pi ft-b(f)\cos 2\pi ft]$, where $\tilde{z}(t)$ is the Hilbert transform of $z(t)$. The distribution $\rho_r(f,\ t)$, called the FTD of the reactive power in [3], is in turn characterized by the envelope $O_r(f,t)=0.5|\rho_R(f,t)|$ and by the phase distribution

$$\theta(f,t)=\varphi(t)+\psi(f)+2\pi ft=\arg[\rho_R(f,t)+4\pi ft,$$

where $\varphi(t)$ = arc tan $(\tilde{z}(t)/z(t)]$ and $\psi(f)$ = arc tan $[b(g)/a(f)]$.

The distribution (2) and its components enable us to extend the concepts of circuit theory, characterizing harmonic oscillations, to functions of two variables for signals described by smooth functions of the instantaneous phase and the envelope. The FTD considered are compared in the table with the corresponding one-dimensional descriptions of a harmonic oscillation.

To estimate the efficiency of the suggested FTD we investigated their properties using the approach described in [1]. It was proved that certain properties lead directly to such traditional concepts of radio engineering as the signal power and its spectrum, the average or instantaneous frequency, the group delay time of a circuit, etc.

The property specified by the following theorem [4] has a special place from the viewpoint of analyzing the FTD:

for signals for the form $z(t)=A(t)\cos\varphi(t)$ ($A(t)$ and $\varphi(t)$ are smooth functions) $\rho_a(f,t)=O_r(f,t)$ in the continuum of points of the frequency-time plane $(\varphi'(t),t)/(2\pi)$.

It enables us to solve efficiently problems of determining the parameters of radio emissions under conditions of a high level of interference.

Finally, the extension of the investigations is shown to be possible by a purposeful synthesis of new FTD having properties specified in advance.

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